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Quantitative EEG Analyses

PATIENT INFORMATION

Name: Mr. Williams
Exam#: CHWIEC1
Age: 21.12 years
Sex: Male
Handedness: Right

Medication: None.

RECORDING

Date: January 24, 2004
Ref. By: Jim Evans
Test Site:
Analysis Length: 2:00 Minutes
Ave. EEG Reliability: 0.97 (SH)
Ave. EEG Reliability: 0.92 (TRT)

HISTORY: The client was retained in first grade, and dropped out of school when 17 and in the ninth grade. He reported some head injuries. One of these occurred when he was 5 or 6 and was hit on the left side of his forehead.The other occurred at about the same age when his sister hit him in the head with a hammer. There now is an indentation in his skull (approximatedly at electrode site PZ). He was in an auto accident at 17, but denies any head injury at that time. He reported that he had overdosed on his Mother's "nerve pills" a couple of months before the crime for which he is incarcerated, and implied that this may have caused him to "lose it mentally" at the time of the crime. He denied any significant history of alcohol or illegal substance use, and said that the only illegal substance he ever used was marijuana. There was a report that his Mother is an alcoholic. He reported a history of childhood sexual abuse by an uncle

SUMMARY OF EEG ANALYSES:

The power spectral analyses were deviant from normal with excessive power in midline posterior regions and especially in the left hemisphere over a wide frequency range. Elevated power was also present in right occipital-parietal regions at 26 - 30 Hz. LORETA 3-dimensional source analyses were consistent with the surface EEG and showed excessive current sources in the left supramarginal gyrus of the parietal lobe and the left superior temporal gyrus with a maximum at 6 Hz (Brodmann areas 13, 39 & 40). Elevated LORETA current sources were present in the middle cingulate gyrus and the mal frontal gyrus with a maximum at 8 Hz (Brodmann areas 6, 24 & 32). Elevated LORETA current sources were

also present in the right inferior and fusiform occipital gyri with a maximum at 28 Hz (Brodmann areas 17, 18 & 19). EEG amplitude asymmetry, EEG coherence and EEG phase were abnormal, especially in bilateral frontal, temporal and parietal-occipital relations. Reduced coherence was present in the bilateral frontal, temporal and parietal-occipital relations which indicates reduced functional connectivity. This condition is often related to reduced speed and efficiency of information processing. The mild traumatic brain injury discriminant function detected a pattern in the EEG that is commonly present in individuals with a history of traumatic brain injury. In summary, the qEEG analyses were deviant from normal and showed de-regulation of the medial frontal lobes, left parietal and bilateral temporal lobes, middle cingulate gyrus and the right occipital lobe. The temporal lobes are involved in auditory information processing, short-term memory, receptive language on the left and face recognition on the right. The left parietal lobe is involved in visual-spatial information processing, short-term memory and receptive language. The cingulate gyrus is involved in volitional motor control and attention control by regulation of limbic emotional and memory input to the cortex. The occipital gyri are involved in visual-spatial information processing and match mismatch of frontal generated expectations and sensory inputs. The frontal regions are involved in mood control, executive functioning, abstract thinking and social skills. To the extent there is deviation from normal electrical patterns in these structures, then sub-optimal functioning is expected.

Robert W. Thatcher

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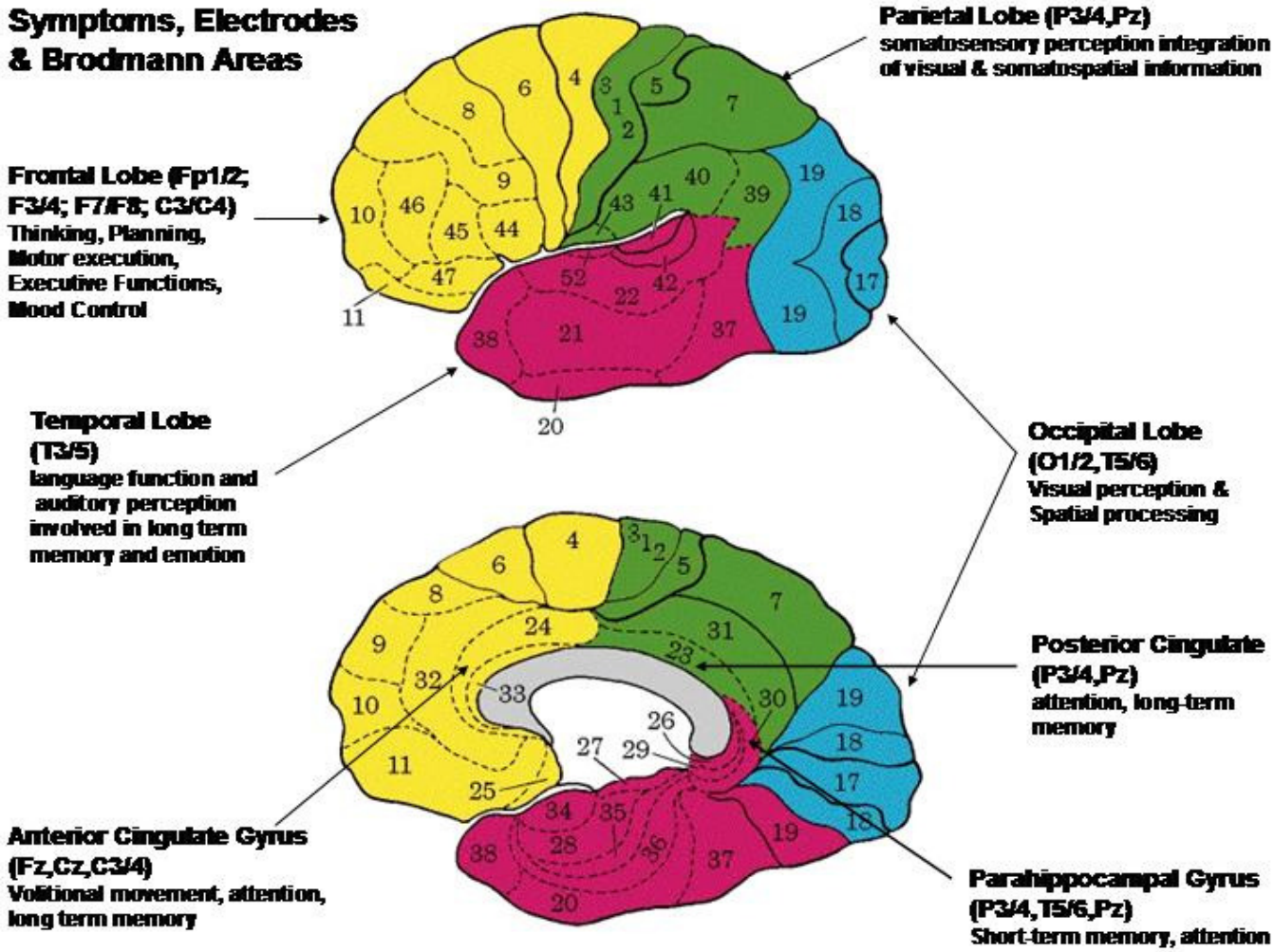
Robert W. Thatcher, Ph.D., QEEG-D, BCIA, ECNS

Electrical NeuroImaging

Linking a patient's symptoms and complaints to functional systems in the brain is important in evaluating the health and efficiency of cognitive and perceptual functions. The electrical rhythms in the EEG arise from many sources but approximately 50% of the power arises directly beneath each recording electrode. Electrical NeuroImaging uses a mathematical method called an "Inverse Solution" to accurately estimate the sources of the scalp EEG (Pascual-Marqui et al, 1994; Pascual-Marqui, 1999). Below is a Brodmann map of anatomical brain regions that lie near to each 10/20 scalp electrode with associated functions as evidenced by fMRI, EEG/MEG and PET NeuroImaging methods.



Conventional EEG Samples and Quantitative EEG Analyses

Fig. 1 - Example of EEG and Absolute Power Z scores – Linked Ears eyes closed condition

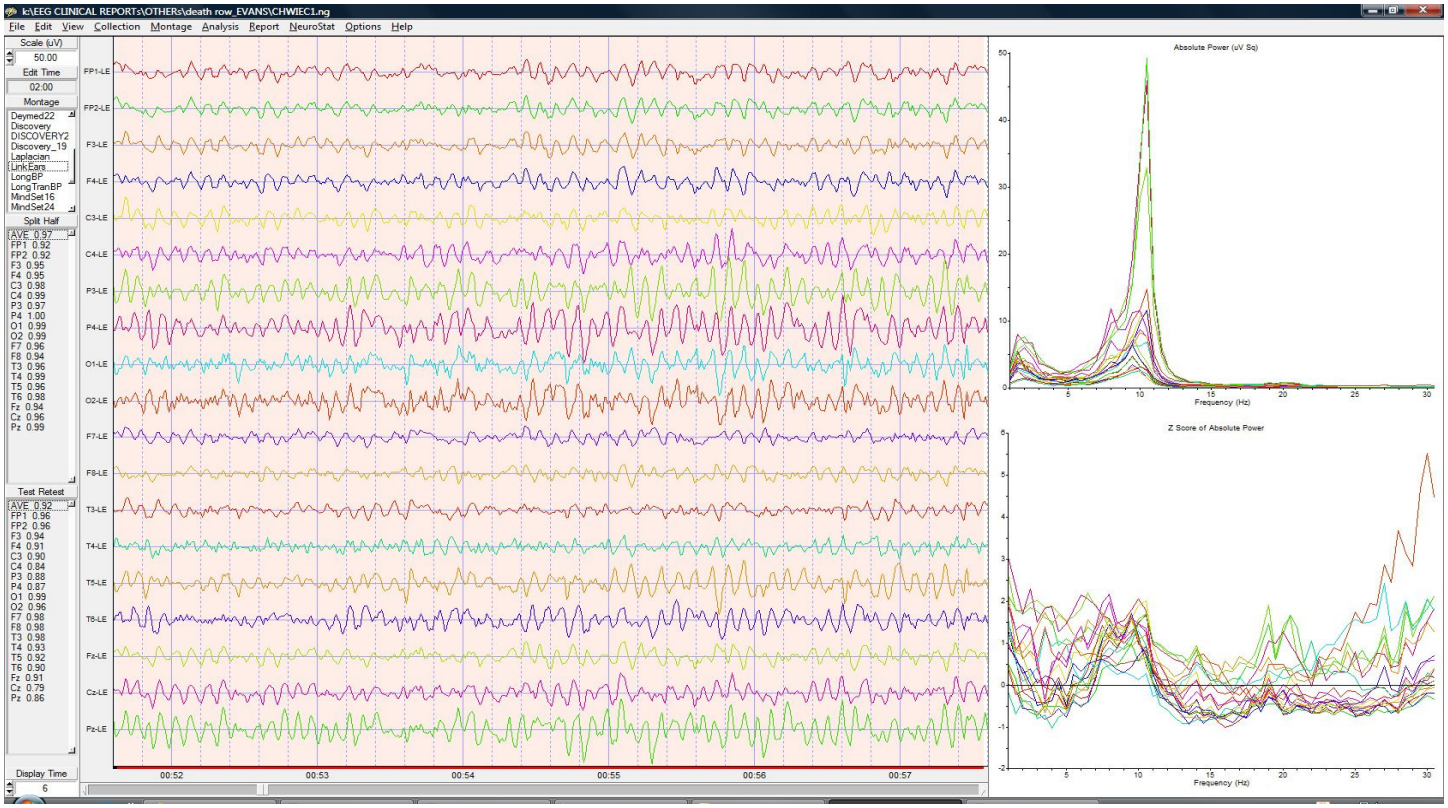


Fig. 2- Example of Laplacian Absolute Power – eyes closed condition

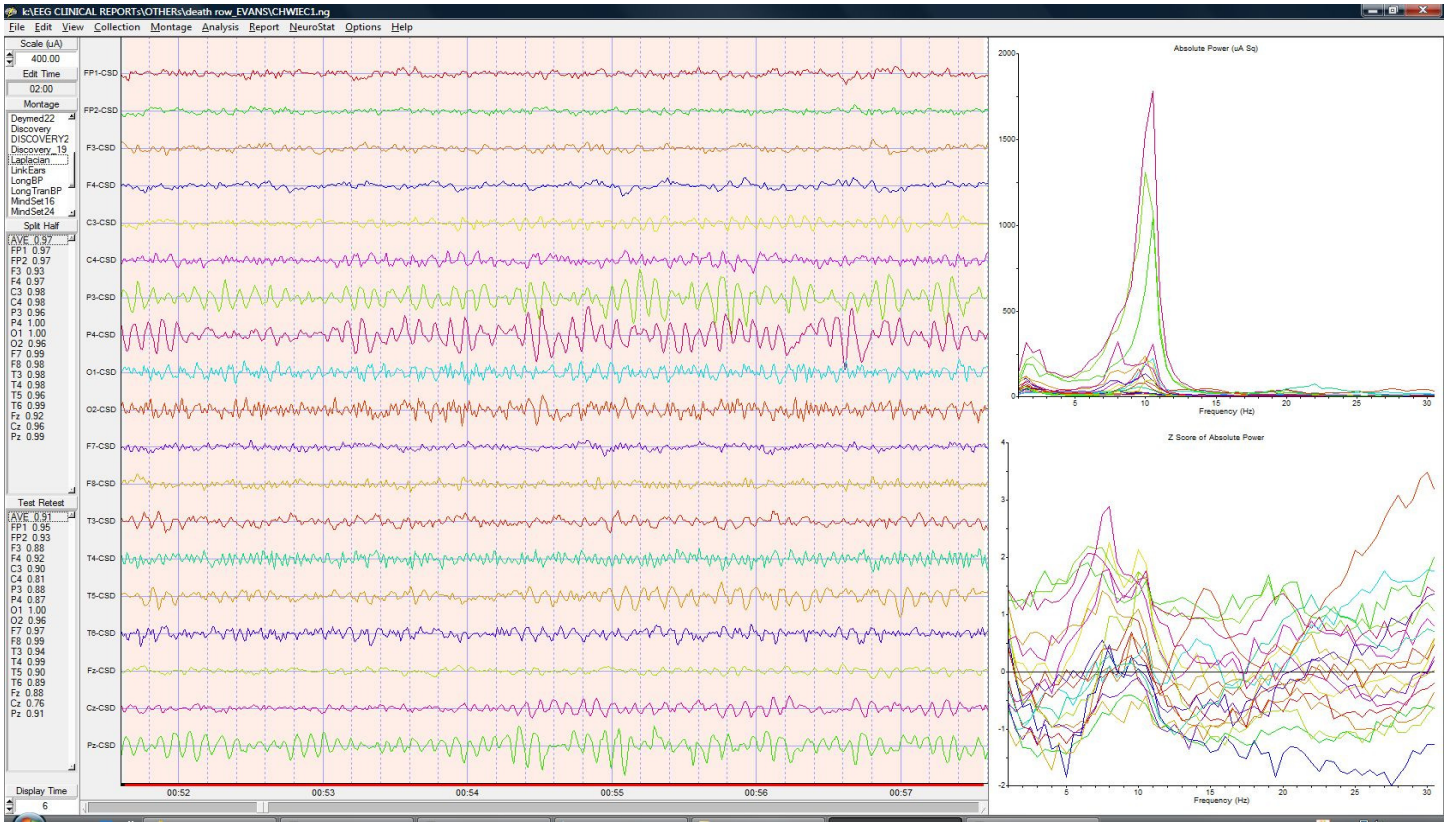


Fig. 3 – Example of LORETA Z Scores at 6 Hz. (Brodmann Area: 13, 39 & 40)

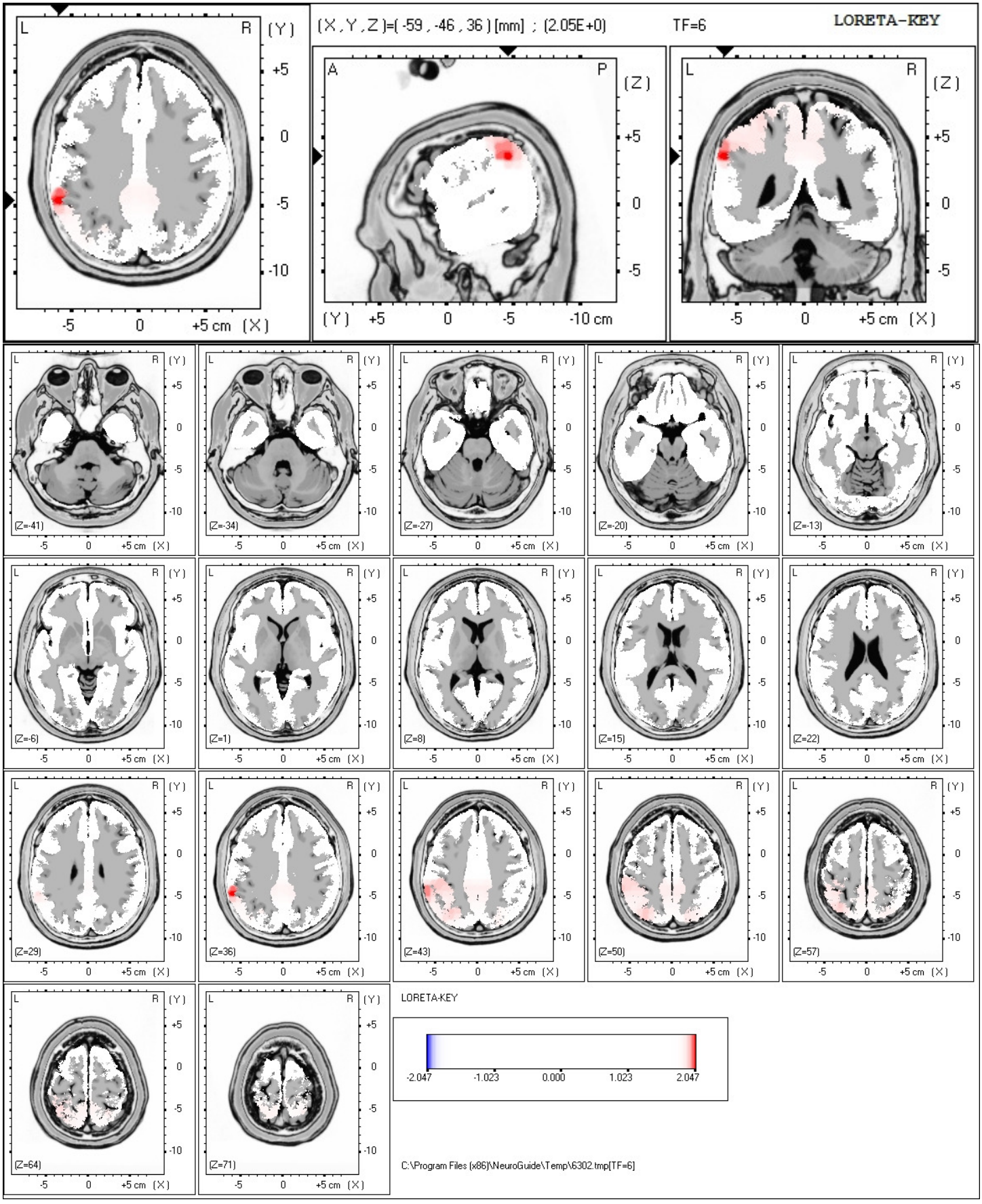


Fig. 4 – Example of LORETA Z Scores at 8 Hz. (Brodmann Area: 6, 24 & 32)

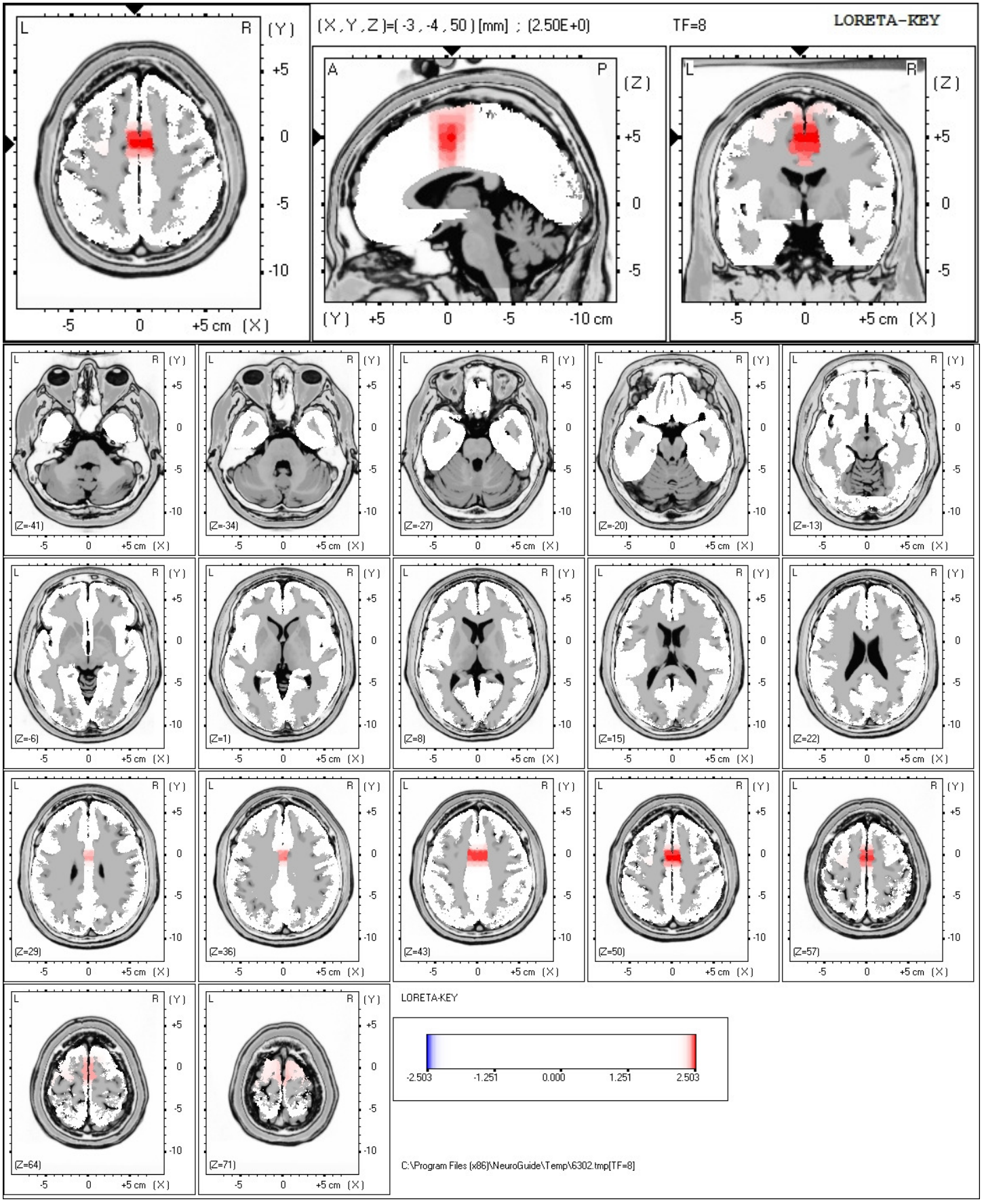
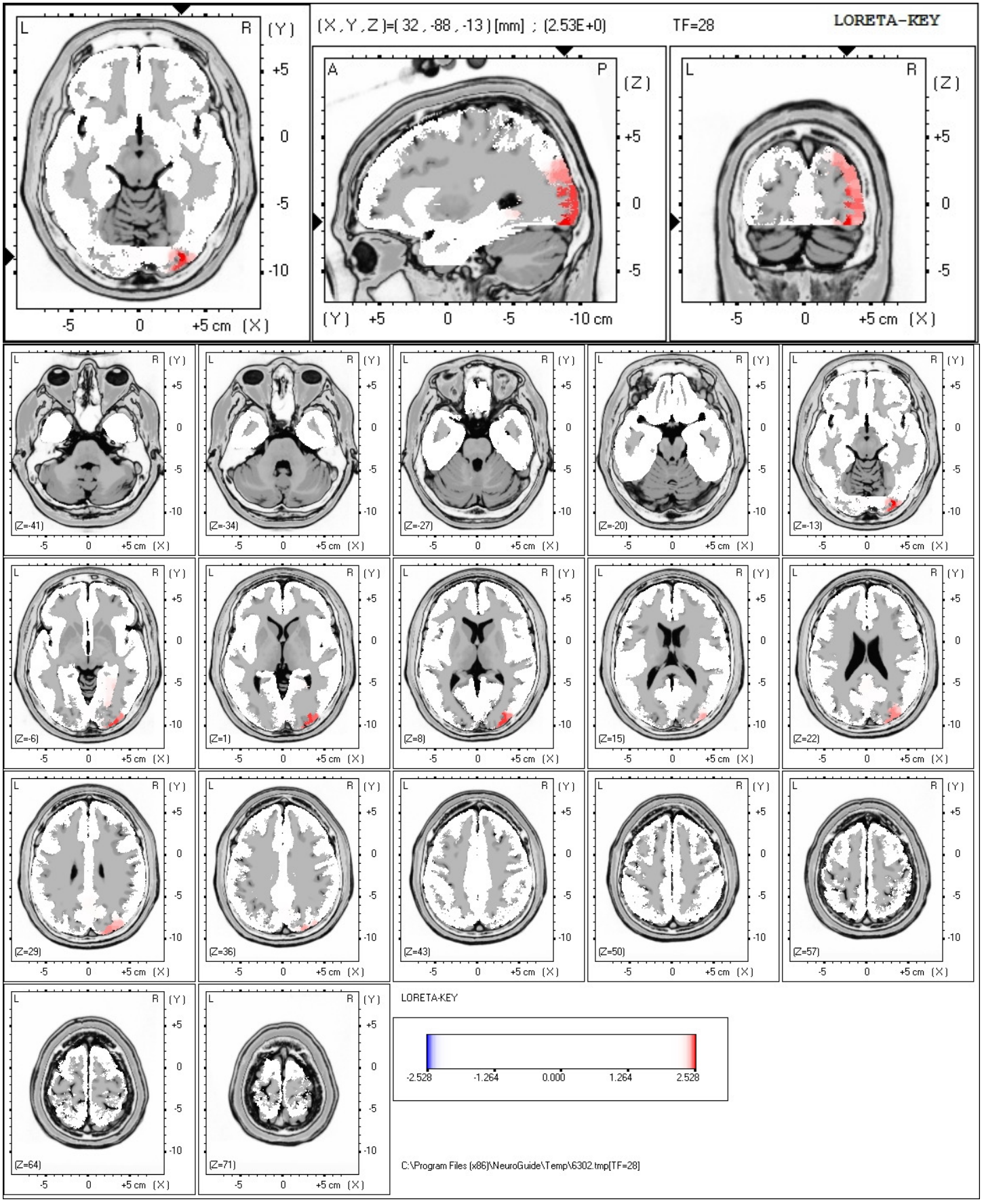
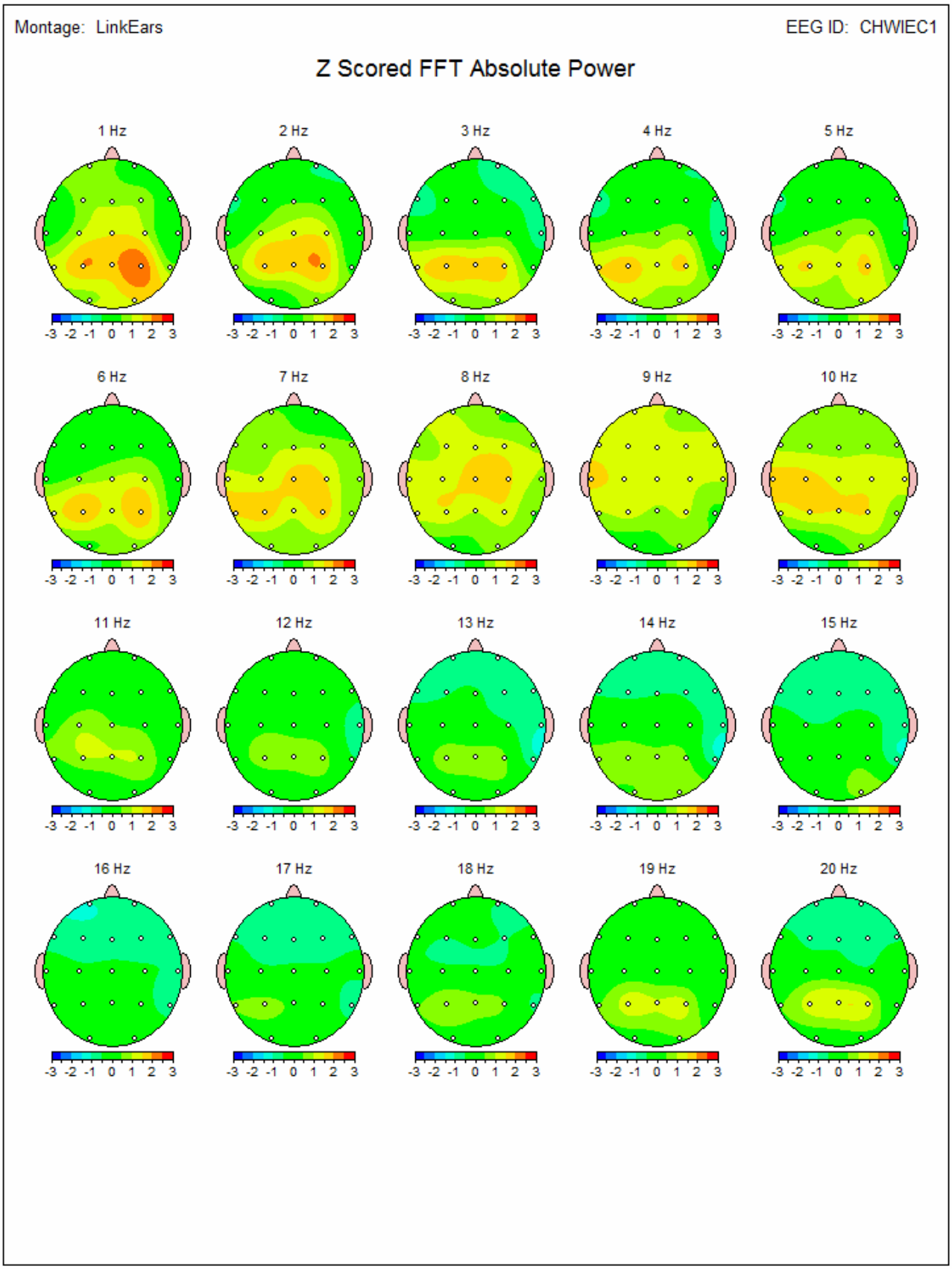
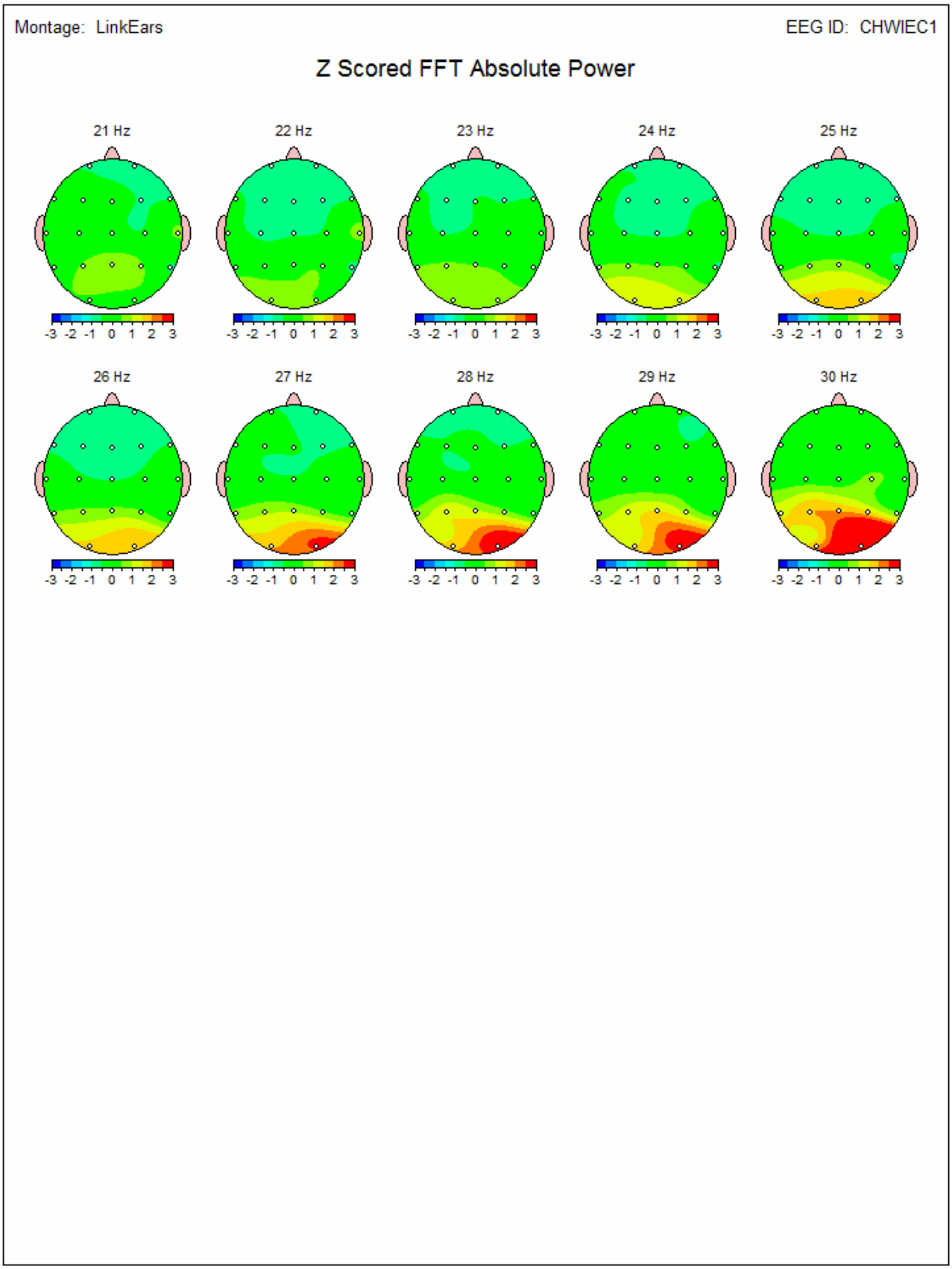
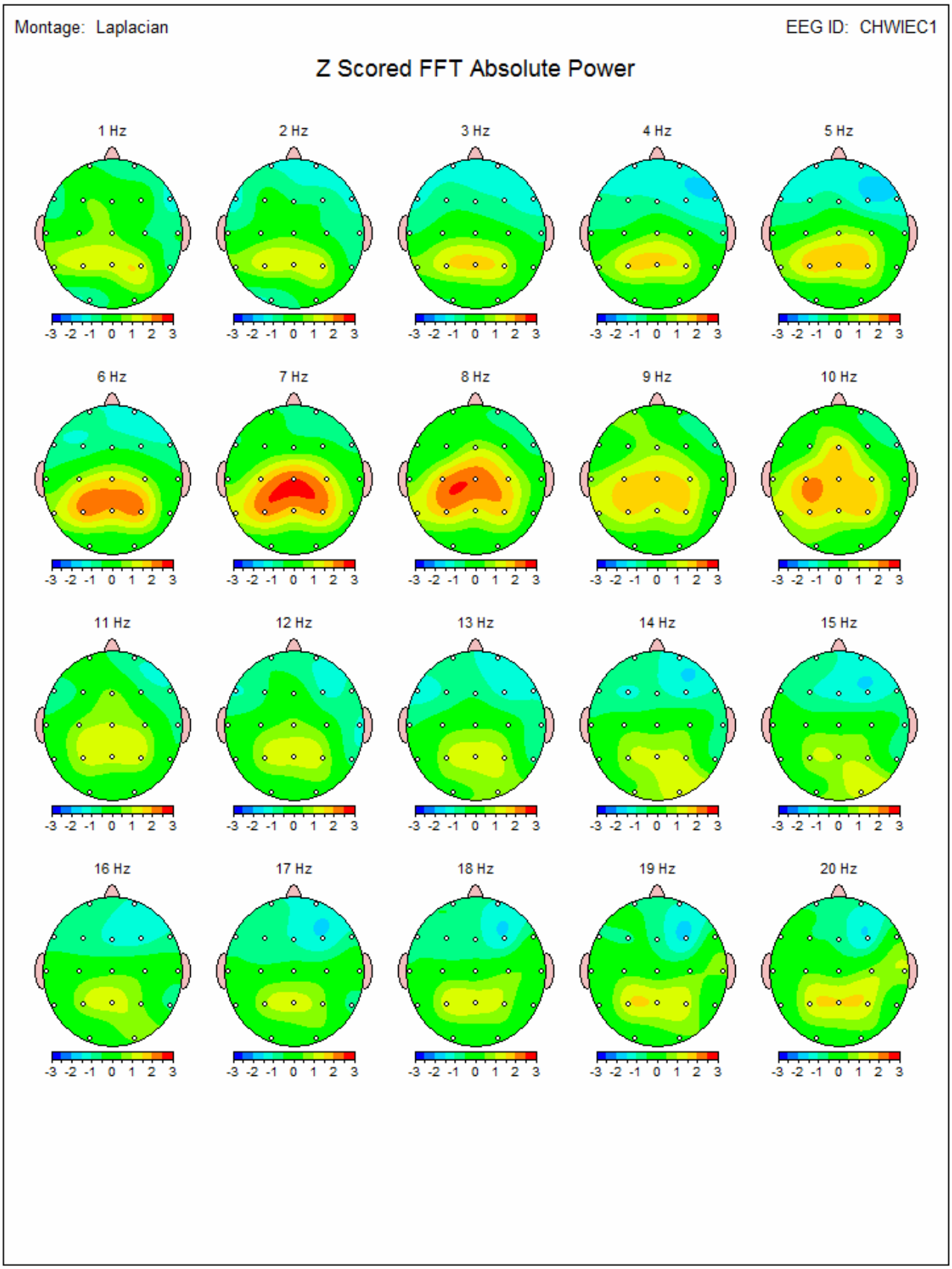


Fig. 5 – Example of LORETA Z Scores at 28 Hz. (Brodmann Area: 17, 18 & 19)



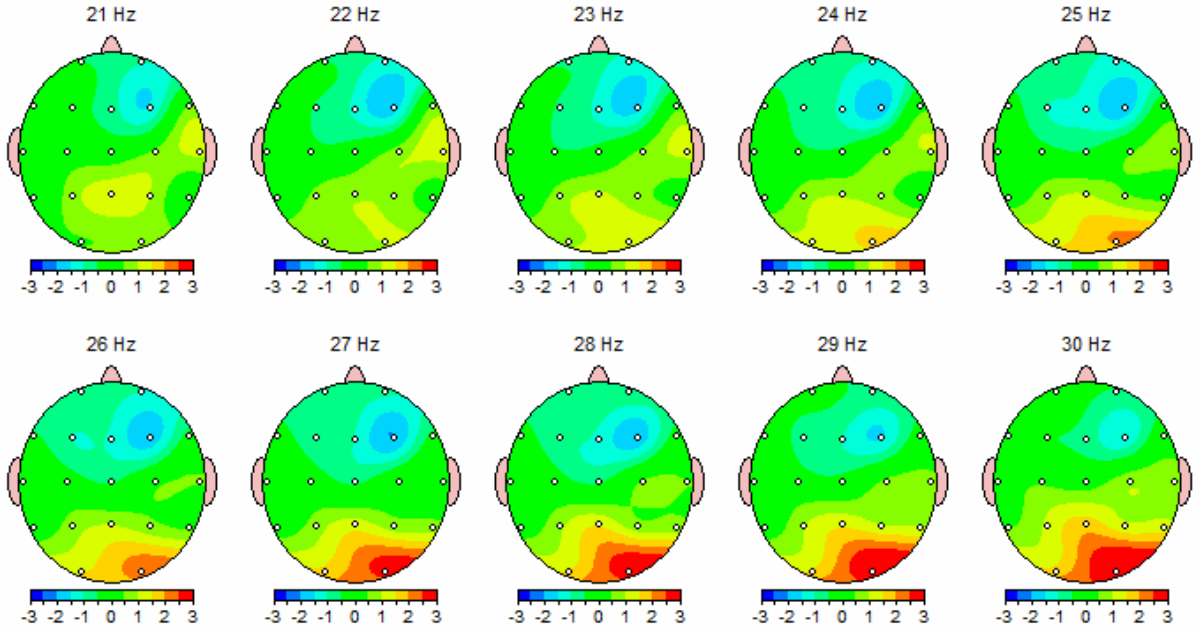

Montage: LinkEars
EEG ID: CHWIEC1
Z Scored FFT Absolute Power
1 Hz
2 Hz
3 Hz
4 Hz
5 Hz
6 Hz
7 Hz
8 Hz
9 Hz
10 Hz
11 Hz
12 Hz
13 Hz
14 Hz
15 Hz
16 Hz
17 Hz
18 Hz
19 Hz
20 Hz
-3 -2 -1 0 1 2 3


Montage: LinkEars
EEG ID: CHWIEC1
Z Scored FFT Absolute Power
21 Hz
22 Hz
23 Hz
24 Hz
25 Hz
26 Hz
27 Hz
28 Hz
29 Hz
30 Hz
-3 -2 -1 0 1 2 3


Montage: Laplacian
EEG ID: CHWIEC1
Z Scored FFT Absolute Power
1 Hz
2 Hz
3 Hz
4 Hz
5 Hz
6 Hz
7 Hz
8 Hz
9 Hz
10 Hz
11 Hz
12 Hz
13 Hz
14 Hz
15 Hz
16 Hz
17 Hz
18 Hz
19 Hz
20 Hz
-3 -2 -1 0 1 2 3

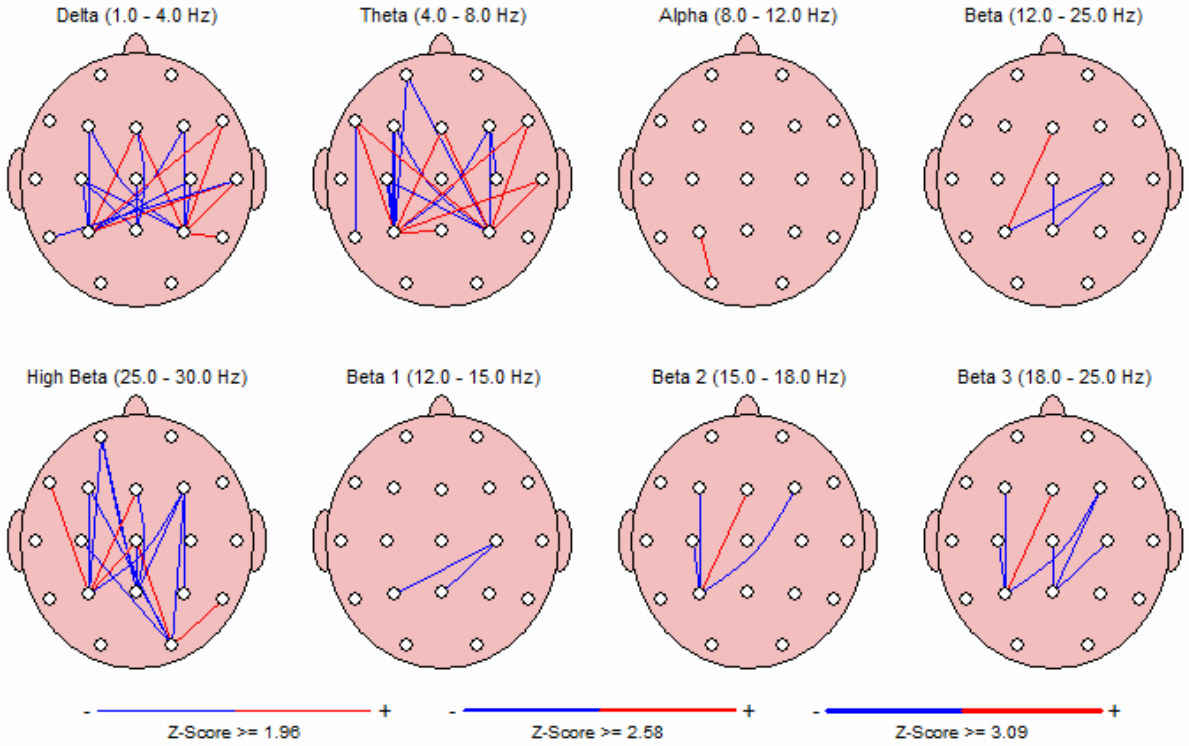
Montage: Laplacian EEG ID: CHWIEC1

Z Scored FFT Absolute Power



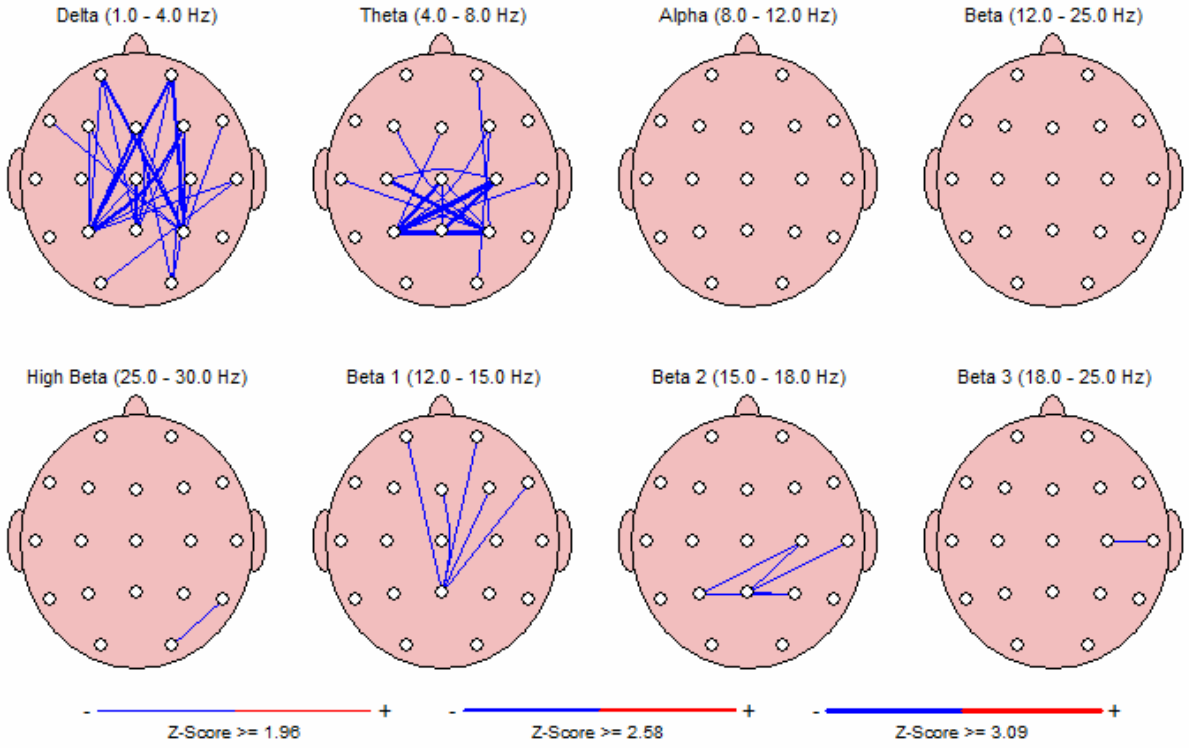
Montage: LinkEars EEG ID: CHWIEC1

Z Scored FFT Amplitude Asymmetry



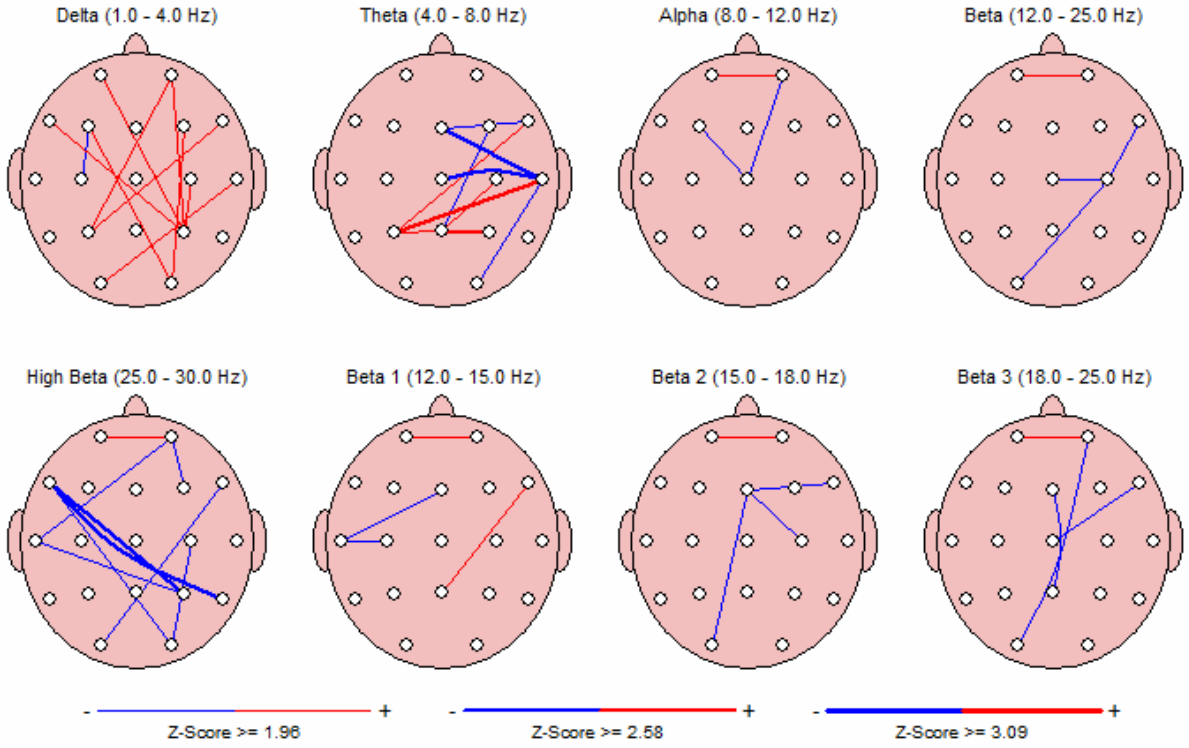
Montage: LinkEars EEG ID: CHWIEC1

Z Scored FFT Coherence



Montage: LinkEars EEG ID: CHWIEC1

Z Scored FFT Phase Lag

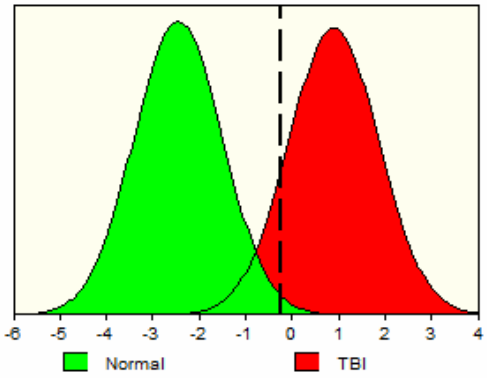


Montage: LinkEars EEG ID: CHWIEC1

Traumatic Brain Injury Discriminant Analysis*

TBI DISCRIMINANT SCORE = -0.28 TBI PROBABILITY INDEX = 85.0%

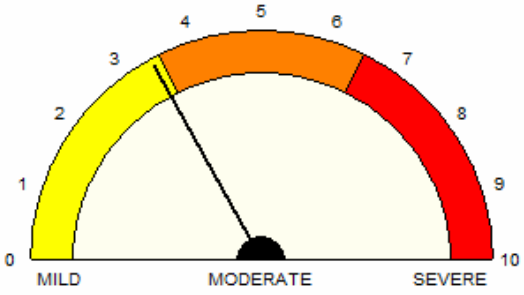
The TBI Probability Index is the subject's probability of membership in the mild traumatic brain injury population. (see Thatcher et al, EEG and Clin. Neurophysiol., 73: 93-106, 1989.)



			RAW	Z
FP1-F3	COH	Theta	87.26	0.95
T3-T5	COH	Beta	71.70	1.65
C3-P3	COH	Beta	73.70	0.37
FP2-F4	PHA	Beta	0.04	-1.35
F3-F4	PHA	Beta	-0.62	0.01
F4-T6	AMP	Alpha	-45.40	0.21
F8-T6	AMP	Alpha	-103.60	0.06
F4-T6	AMP	Beta	-31.47	-0.51
F8-T6	AMP	Beta	-72.36	-0.26
F3-O1	AMP	Alpha	-30.36	1.11
F4-O2	AMP	Alpha	-69.65	0.43
F7-O1	AMP	Alpha	85.03	-1.13
F4-O2	AMP	Beta	-92.08	-0.91
P3	RP	Alpha	70.14	1.09
P4	RP	Alpha	72.41	1.18
O1	RP	Alpha	55.69	-0.26
O2	RP	Alpha	64.20	0.24
T4	RP	Alpha	52.37	1.25
T5	RP	Alpha	59.35	0.53
T6	RP	Alpha	67.83	0.88

TBI SEVERITY INDEX = 3.39

This severity score places the patient in the MILD range of severity.



			RAW	Z
FP1-C3	COH	Delta	48.63	0.15
FP1-FP2	COH	Theta	94.27	1.45
O1-F7	COH	Alpha	35.73	0.17
O2-T6	COH	Alpha	89.66	0.77
P3-O1	COH	Beta	72.62	-0.04
FP1-T3	PHA	Theta	0.21	-1.64
T3-T4	PHA	Theta	76.64	1.07
O1-F7	PHA	Alpha	-39.09	0.47
F7-F8	PHA	Alpha	-0.07	-1.62
T5-T6	PHA	Beta	3.08	-0.04
C3-F7	AMP	Delta	71.09	0.59
FP2-F4	AMP	Delta	-16.26	0.09
C4-F8	AMP	Delta	67.92	0.62
O1-O2	AMP	Theta	-8.91	-0.27
P3-F7	AMP	Alpha	157.89	0.79
FP2-P4	AMP	Alpha	-151.10	-1.00

The TBI Severity Index is an estimate of the neurological severity of injury. (see Thatcher et al, J. Neuropsychiatry and Clinical Neuroscience, 13(1): 77-87, 2001.)

***Statement of Indications of Use:**

The Discriminant Analysis and Severity Index are to be used by experienced and qualified professionals for the post-hoc statistical evaluation of the human electroencephalogram (EEG). The Discriminant Analysis and Severity Index are to be viewed as an adjunct to the evaluation of the patient, and they do not serve as a primary basis for a diagnosis. Warning: Inclusion criteria of a history of traumatic brain injury and greater than 13 years of age must be adhered to.

Montage: LinkEars EEG ID: CHWIEC1

Technical Information

Record Length: 04:24

Edit Length: 02:00

Reliability:

	Split Half	Test Retest
Average	0.97	0.92
FP1	0.92	0.96
FP2	0.92	0.96
F3	0.95	0.94
F4	0.95	0.91
C3	0.98	0.90
C4	0.99	0.84
P3	0.97	0.88
P4	1.00	0.87
O1	0.99	0.99
O2	0.99	0.96
F7	0.96	0.98
F8	0.94	0.98
T3	0.96	0.98
T4	0.99	0.93
T5	0.96	0.92
T6	0.98	0.90
Fz	0.94	0.91
Cz	0.96	0.79
Pz	0.99	0.86

Sampling Rate: 128

Collection Hardware: Lexicor (High Pass Off)

An Addendum to Neuroguide QEEG Report

Important disclaimer - QEEG tests are ancillary tests that are not intended to provide a diagnosis by themselves, but are used to evaluate the nature and severity of deregulation in the brain such as in mild traumatic brain injury. The QEEG tests provide a quantitative assessment of areas of brain dysfunction and information on impaired conduction and connectivity between different regional neural networks in the brain. The assessment of impaired connectivity is based on abnormal measurements of Coherence and Phase.

The TBI Discriminant does not provide a diagnosis for MTBI but only information on the presence of a pattern in the EEG that is often found in patients with a history of mild traumatic brain injury. The TBI discriminant also provides information about connectivity and excitability of brain regions.

The TBI discriminant is to be used only on patients with a clinical history and symptoms of a Traumatic Brain Injury and Post Concussion syndrome.

The diagnosis of MTBI is a clinical one and is not based on any one test. A diagnosis is performed by the clinician, who integrates the medical history, clinical symptoms, neurocognitive tests with the above mentioned brain function tests as well as other information to render a diagnosis.

The information on impaired brain connectivity is derived primarily from abnormal measurements of Coherence and Phase. Assessments of regional abnormality rely also on abnormal amplitude (power) distribution across the spectrum of EEG frequencies as compared to the normative database.

Description of the Neuroguide Normative Database:

The NeuroGuide normative database in versions 1.0 to 2.4.6 included a total of 625 carefully screened individual subjects ranging in age from 2 months to 82 years. NG 2.5.1 (6/12/2008) involved the addition of 53 adult subjects ranging in age from 18.3 years to 72.6 years resulting in a normative database of 678 subjects. The inclusion/exclusion criteria, demographics, neuropsychological tests, Gaussian distribution tests and cross-validation tests are described in several peer reviewed publications (Thatcher et al, 1983; 1987; 2003). Two year means were computed using a sliding average with 6 month overlap of subjects. This produced a stable and higher age resolution normative database with a total of 21 different age groups. The 21 age groups and age ranges and number of subjects per age group is shown in the bar graph in Appendix F figure 2 in the NeuroGuide Manual (click Help > NeuroGuide Help).

The individuals used to create the normative database met specific clinical standards of no history of neurological disorders, no history of behavioral disorders, performed at grade level in school, etc. Most of the subjects in the normative database were given extensive neuropsychological tests. Details of the normative database are published at: Thatcher, R.W., Walker, R.A. and Guidice, S. Human cerebral hemispheres develop at different rates and ages. Science, 236: 1110-1113, 1987 and Thatcher R.W., Biver, C.L., North, D., Curtin, R. and Walker, R.W. Quantitative

EEG Normative Databases: Validation and Clinical Correlation. Journal of Neurotherapy, 2003, 7(3/4): 87-121. You can download a description of the normative database by going to www.appliedneuroscience,com and clicking on the webpage Articles & Links > Articles > Article #5.

Is there a normative database for different montages including bipolar montages?

Yes. The raw digital data from the same group of normal subjects is analyzed using different montages such as Average Reference, Laplacian current source density, a common reference based on all

19 channels of the 10/20 system and standard clinical bipolar montages (e.g., longitudinal, circular, transverse). Users can create any montage that they wish and there will be a normative reference database comparison available for both eyes closed and eyes open conditions

Age range of the LORETA current density and Source Correlation normative databases

The LORETA current density and source correlation norms use the same subjects as are used for the surface EEG norms and the age range is 2 months to 82 years. The computational details of the LORETA current density norms are published at: Thatcher, R.W., North, D., Biver, C. EEG inverse solutions and parametric vs. non-parametric statistics of Low Resolution Electromagnetic Tomography (LORETA). Clin. EEG and Neuroscience, Clin. EEG and Neuroscience, 36(1), 1 – 9, 2005 and Thatcher, R.W., North, D., Biver, C. Evaluation and Validity of a LORETA normative EEG database. Clin. EEG and Neuroscience, 2005, 36(2): 116-122. Copies of these publications are available to download from www.appliedneuroscience,com by clicking Articles & Links > Articles > Numbers 11 and 12. The computational details of the LORETA source correlation norms are in the NeuroGuide manual, click Help > NeuroGuide help > Appendix-G

Implementation of LORETA measurement in Neuroguide

The Key Institute's LORETA equations and the LORETA viewer (Pacual-Marqui et al, 1994; Pascual-Marqui, 1999) can be launched by a single mouse click in the NeuroGuide window. NeuroGuide Deluxe exports frequency domain and time domain edits of 19 channel x 256 point digital EEG in microvolts (or uv^2) in the Lexicor electrode order as the standard input to the Key Institute T-Matrix. Rows are 256 microvolt time points and the columns are 19 channels at a sample rate of 128 thus producing 0.5 Hz resolution from 1 to 30 Hz. 1 Hz increments in the LORETA viewer are computed as the sum of adjacent 0.5 Hz bins and thus the 'Time Frame' control in the LORETA Viewer is frequency from 1 to 30 Hz. (see Pascual-Marqui RD, Michel CM, Lehmann D., 1994. Low resolution electromagnetic tomography: a new method for localizing electrical activity in the brain. International Journal of Psychophysiology 18:49-65. For computational details see: Pascual-Marqui. R.D., 1999. Review of Methods for Solving the EEG Inverse Problem. International Journal of Bioelectromagnetism, Volume 1, Number 1, pp:75-86. Pascual-Margui, R.D., 2004. Free software and documentation from the Key Institute that was downloaded from http://www.unizh.ch/keyinst/NewLORETA/Software/Software.htm.)

There is a need to match different amplifiers to the amplifier on which the Neuroguide amplifier that acquired the original database information.

This stems from the fact that amplifiers have different frequency gain characteristics. The matching of amplifiers to the Neuroguide database amplifier was done by injecting microvolt calibration signals of different amplitudes and frequencies into the input of the respective EEG machines and then computing correction curves to exactly match the amplifier characteristics of the norms and discriminant functions. The units of comparison are in microvolts and a match within 3% is generally achieved. The Neuroguide research team double checked the amplifier match by computing FFT and digital spectral analyses on calibration signals used to acquire the norms with the calibration signals used to evaluate a given manufacturers amplifiers.

History of the Scientific Standards of QEEG Normative Databases

A review of the history of QEEG normative databases was published in Thatcher, R.W. and Lubar, J.F. History of the scientific standards of QEEG normative databases. In: Introduction to QEEG and Neurofeedback: Advanced Theory and Applications, T. Budzinsky, H. Budzinsky, J. Evans and A. Abarbanel (eds)., Academic Press, San Diego, CA, 2008. A copy of the publication can be downloaded at: http://www.appliedneuroscience.com/HistoryofQEEG%20Databases.pdf

QEEG Normative Database Publications and Validations:

\Bosch-Bayard J, Valdes-Sosa P, Virues-Alba T, Aubert-Vazquez E, John ER, Harmony T, Riera-Diaz J, Trujillo-Barreto N. (2001). 3D statistical parametric mapping of EEG source spectra by means of variable resolution electromagnetic tomography (VARETA). Clin Electroencephalogr., 32(2):47-61.

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